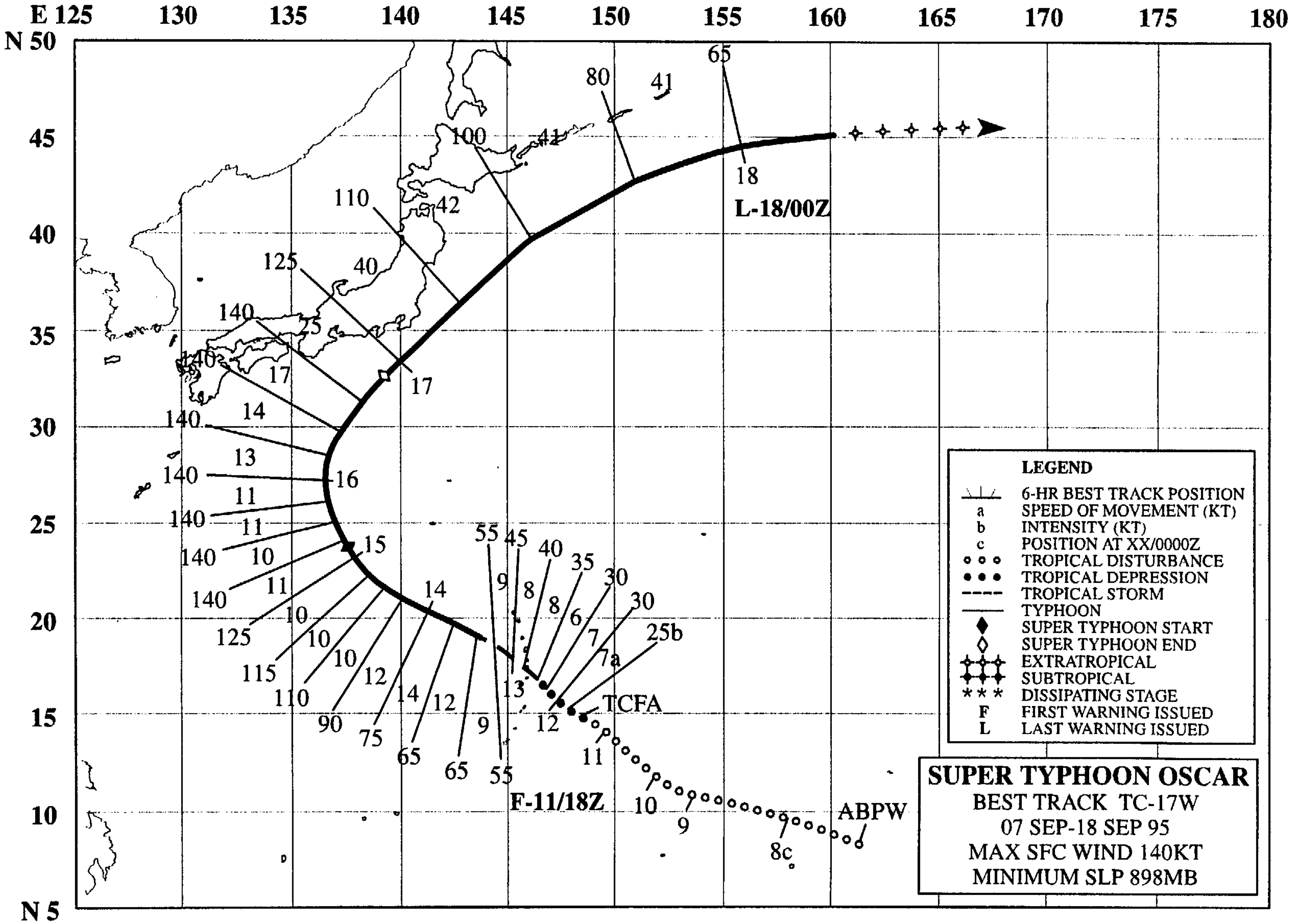
SUPER TYPHOON OSCAR
BEST TRACK TC-17W
07 SEP-18 SEP 95
MAX SFC WIND 140KT
MINIMUM SLP 898MB
LEGEND
6-HR BEST TRACK POSITION
a SPEED OF MOVEMENT (KT)
b INTENSITY (KT)
c POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
SUBTROPICAL
DISSIPATING STAGE
F FIRST WARNING ISSUED
L LAST WARNING ISSUED
E 125
130
135
140
145
150
155
160
165
170
175
180
N 50
45
40
35
30
25
20
15
10
N 5
L-18/00Z
F-11/18Z
TCFA
ABPW

SUPER TYPHOON OSCAR (17W)

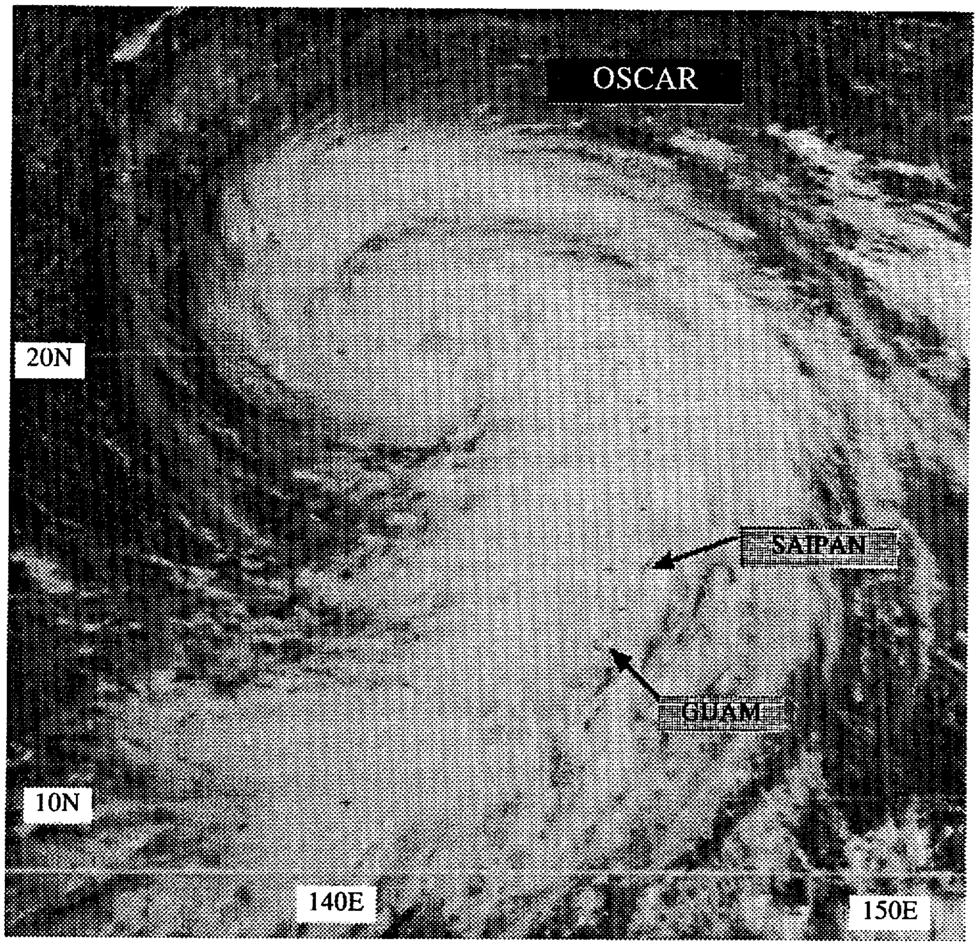

Figure 3-17-1 As Oscar becomes a typhoon, its cloud system covers a large area of the Pacific near the Mariana Islands (132131Z September visible GMS imagery).

I. HIGHLIGHTS

Forming at the eastern end of a monsoon trough which later became reverse-oriented, Oscar became a large tropical cyclone (Figure 3-17-1). Oscar also became a very intense tropical cyclone (Figure 3-17-2), reaching a peak intensity of 140 kt (72 m/sec). When the typhoon passed through the point of recurvature, it posed a serious threat to Tokyo and the southeastern coast of Japan. However, it turned far enough eastward to give only a glancing blow to extreme southeastern Honshu; the eye remained offshore as it passed about 100 nm (185 km) southeast of Tokyo. Oscar's rapid speed of translation — in excess of 40 kt (75 km/hr) — helped to spare Japan the full effects of the typhoon's highest winds. Nevertheless, heavy rain and high winds were responsible for loss of life, and some minor damage in Japan.

II. TRACK AND INTENSITY

Prior to the formation of Oscar, Tropical Storm Nina (15W) moved through the South China Sea. The southwest monsoon was well-established across the South China Sea, but extended only as far east as the Philippines. Elsewhere in the tropics, low-level winds were light, sea-level pressure was slightly above normal, and deep convection was scattered in disorganized clusters throughout Micronesia. Then, on 07 September, the amount of deep convection began to increase in a broad area bounded by the equator and 20°N from 140°E to 170°E. A tropical disturbance was first mentioned on the 070600Z September Significant Tropical Weather Advisory: synoptic data indicated that a weak low-level cyclonic circulation center accompanied an area of convection near 8°N 163°E. By 11 September, the monsoon trough axis had lifted northward and extended past Guam to about 150°E. For the first time during 1995, Guam experienced monsoonal low-level southwesterly wind. At the eastern reaches of this monsoon trough (about 200 nm northeast of Guam), deep convection began to organize around a low-level circulation center, prompting the JTWC to issue a Tropical Cyclone Formation Alert at 111430Z. The JTWC issued the first warning, valid at 111800Z on Tropical Depression 17W. This was based on increased amounts of deep convection, the improved organization of the lines of deep convection and the pattern of the cirrus outflow. The island of Guam lay under one of the bands of deep convection. Lowering sea-level pressure, heavy rains, and gusty westerly winds confirmed the development of Tropical Depression 17W.

During the next two days, Oscar intensified, becoming a tropical storm at 121200Z, a typhoon at 131200Z, and a super typhoon at 150600Z. Even more noteworthy than the fairly rapid intensification of Oscar was its large size (Figures 3-17-1 and 3-17-2) (see the discussion section for comments on Oscar's large size). Near its point of recurvature, Oscar's radius of gales reached outward to 335 nm (620 km).

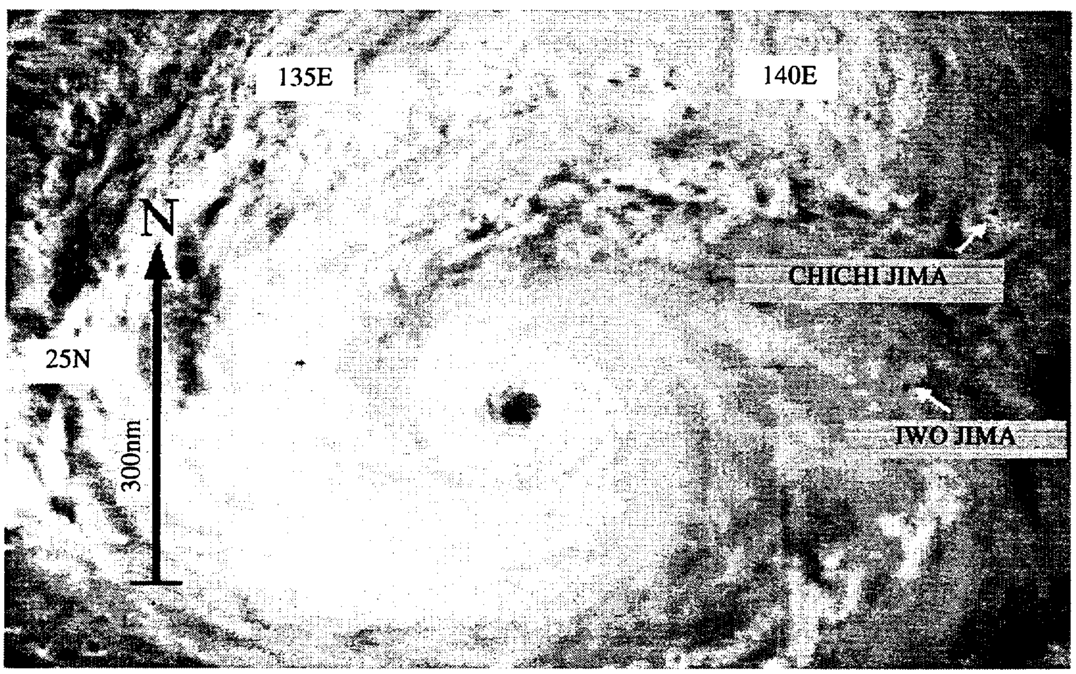

Figure 3-17-2 Oscar reaches its peak intensity of 140 kt (72 m/sec) (150730Z September visible GMS imagery).

Oscar reached its point of recurvature at 160000Z September when it was about 500 nm (925 km) southwest of Tokyo. At this point, forecast guidance and the synoptic situation suggested that Oscar would accelerate rapidly to the northeast and pass very close to Tokyo. During this very critical period, the JTWC forecasts were for landfall near Tokyo. Not until 170000Z did the official forecast take Oscar offshore about 90 nm (170 km) east-southeast of Tokyo. The following chronology of comments on JTWC warnings leading up to Oscar's closest point of approach (CPA) to Tokyo was extracted from the JTWC Deputy Director's unofficial electronic logbook:

"Warning #14 (15/0000Z): TY Oscar continues NWward 320 @ 09 knots. Forecasting super TY around 16/12Z. Track forecast follows the NO [north-oriented] pattern with slow turn NEward. This is the first forecast that makes landfall on Japan. Tokyo/Yokosuka around 17/06Z."

"Warning #19 (16/0600Z): STY Oscar's course has become more northward indicating the slow turn to the NEward track is occurring. (005@11 KTS). System will pass very close to Tokyo around 17/06. In fact, forecasting for landfall on Tokyo at 17/06Z."

"Warning #23 (17/0000Z): Oscar turned sharper to the right than forecasted. Now forecasting for about 60 nm's off the coast around 17/03Z."

"Warning #25 (17/1800Z): Tracking 046 @ 46 knots rapidly transitioning to ET [extratropical]." The final warning, valid at 180000Z, was issued by the JTWC when Oscar was deemed to have transitioned into a vigorous extratropical low moving rapidly eastward along 45°N.

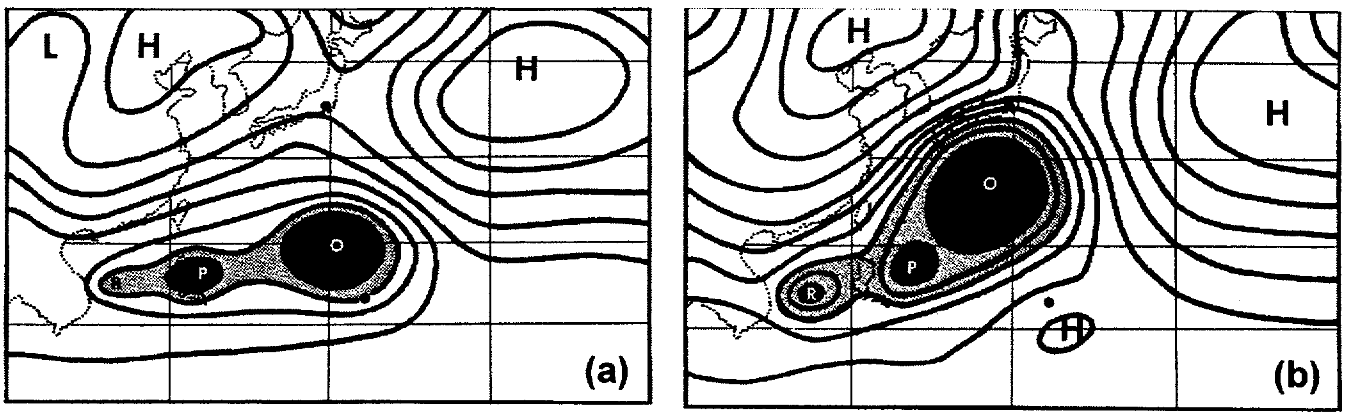

Figure 3-17-3 Sea-level pressure (SLP) analysis over the western North Pacific basin at 140000Z September (a), and 160000Z September (b). Three tropical cyclones — Oscar (O), Polly (18W) (P), and Ryan (19W) (R)— formed simultaneously along a reverse-oriented monsoon trough. Oscar's large size is indicated by its large average radius of outermost closed isobar which has a value of approximately 500 nm in (b). Solid lines are isobars at 2 mb intervals. In (a), the shaded region shows where SLP is lower than 1006 mb, the black areas are below 1004 mb. In (b), the shaded region shows where SLP is lower than 1006 mb, the black areas are below 1002 mb. The 1002 mb isobar in (b) is the outermost closed isobar of Oscar at that time.

III. DISCUSSION

a. *Development in a reverse-oriented monsoon trough.*

Oscar was the first of three tropical cyclones — the other two were Polly (18W) and Ryan (19W) — to develop along the axis of a reverse-oriented monsoon trough that stretched from the South China Sea east-northeastward into the Pacific Ocean north of Guam (Figure 3-17-3a). Oscar was the eastern-most tropical cyclone of the three. For a more detailed discussion of the reverse-oriented monsoon trough within which Oscar, Polly (18W) and Ryan (19W) developed, and its association with unusual motion of Polly and Ryan, see the discussion section in Polly's (18W) summary.

b. *Largest TC of 1995*

Super Typhoon Oscar was the largest tropical cyclone of 1995. Using the mean radius to the outermost closed isobar (ROCI) as a measure of Oscar's size, the system reached the threshold of the "very large" size category used by the JTWC (see Appendix A). At its largest, the mean ROCI was about 8° of great circle arc (GCA) (Figure 3-17-3b). Interestingly, the large expanse of cyclonically curved low-level wind flow surrounding Oscar, and the extensive amounts of cyclonically curved lines of low-level cumulus and deep convection surrounding Oscar (e.g., see Figure 3-17-2), extend significantly beyond the mean ROCI.

Tropical cyclone size is a very difficult parameter to objectively measure. Merrill (1984) classified a tropical cyclone as "small" if the mean ROCI was three degrees (180 nm, 335 km) GCA, or smaller; as "medium" if the mean ROCI was between three to five degrees GCA (180 nm to 300 nm ; 335 km to 555 km), and as "large" if the mean ROCI was greater than five degrees GCA (greater than 300 nm, 555 km). The Japan Meteorological Agency recognizes two additional size categories — "very small" and "ultra large" — that mesh neatly with Merrill's scheme (See Table 3-17-1). The definitions of size used herein (see Appendix A) have been adapted by a mesh of the JMA size categories with those of Merrill.

Table 3-17-1 Categories of tropical cyclone size based upon the average radius of the outermost closed isobar.

SIZE CATEGORY	RADIUS OF OUTERMOST CLOSED ISOBAR (Degrees)	Nautical Miles
VERY SMALL	<2	<120
SMALL	2-3	120-180
AVERAGE	3-6	181-360
LARGE	6-8	361-480
VERY LARGE	>8	>480

c. *High speed of translation east of Japan*

While passing close to the eastern shores of the Japanese main island of Honshu, Oscar's speed of translation increased to values in excess of 40 kt (75 km/hr). The result of this rapid translation was a drastic reduction of the radial extent of high wind speeds to the left of Oscar's track, sparing Japan the full effects of Oscar's highest winds. A reasonable first approximation of the wind asymmetries in a tropical cyclone is to simply add the speed of translation to the vortex intensity on the right side — the so called dangerous semicircle — and to subtract the speed of translation from the vortex intensity on the left side, or weak semicircle. NEXRAD cross sections of tropical cyclones passing near Guam (see the discussion section of Super Typhoon Ward (25W)), and other composites of tropical cyclone wind structure show that this simple picture of tropical cyclone wind distribution is reasonable in the tropics. As tropical cyclones recurve into mid latitudes, it is not clear that the wind asymmetries are so simple. Indeed, the concepts of the "dangerous semicircle", where the vortex intensity is enhanced by the addition of translation, and the weak semicircle, where the vortex winds are reduced by the speed of translation are still valid to a large extent. However, as the case with Oscar shows, there are some fundamental properties of fast moving recurving tropical cyclones that need to be clarified.

There are insufficient data to allow one to accurately determine the wind distribution in Oscar as it sped past Japan, but one can analytically derive two possible wind distributions given two different interpretations of the warning intensity. If the intensity of a tropical cyclone is considered to be representative of the peak winds in the dangerous semicircle, one must subtract twice the translation speed from this wind in order to obtain the highest wind on the left side (given a uniform steering flow). In Oscar's case, if the peak winds were 120 kt on the right side of the storm, then, given its 40-kt translation speed, the peak winds on the left side could have been only 40 kt (i.e., 120 kt minus 80 kt). Mathematically, the shape of the isotachs surrounding a tropical cyclone with such a wind distribution will be bean-shaped (Figure 3-17-4). Given the warning radius of 50 kt winds of 220 nm (410 km) on the right side of Oscar, it is possible that 50 kt winds extended only 40 nm (75 km) to the left of Oscar's track in two lobes northwest and southwest of the center (Figure 3 -17-4).

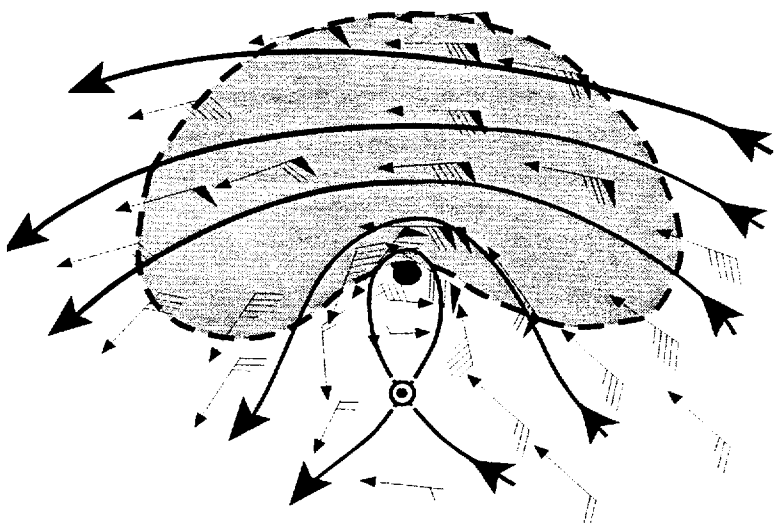

Figure 3-17-4 The analytical wind distribution for a tropical cyclone that is composed of an 80 kt symmetric vortex embedded in a 40 kt unidirectional steering flow. Large dot shows the cyclone center, solid lines are streamlines, and the dotted line shows the area of winds of 50 kt or greater.

If the intensity of a tropical cyclone is considered to be the intensity of the symmetrical portion of the tropical cyclone wind field (i.e., the translation speed is not considered), then the isotachs are shaped as above, only now the peak wind in the dangerous semicircle of a 120 kt tropical cyclone is 160 kt (i.e., 120 kt plus 40 kt), and in the weak semicircle (i.e., to the left of the track) it is only 80 kt. Now, given the warning radius of 50 kt winds of 220 nm (410 km) on the right side of Oscar, wind speeds of 50 kt (26 m/sec) extend 60 nm (110 km) directly to the left of the track, and nearly 100 nm to the left of the track in two lobes to the northwest and southwest. The wind distribution of a tropical cyclone that is rapidly accelerating following recurvature, and that is becoming extratropical is certainly a topic worthy of further study. This topic is of interest especially since the Dvorak technique does not explicitly address translational effects on intensity and wind distribution.

d. *Time series of the "digital Dvorak" (DD) number*

One of the utilities installed in the MIDDAS satellite image processing equipment is an automated routine for computing Dvorak "T" numbers for tropical cyclones that possess eyes. The routine, developed by Zehr (personal communication), adapts the rules of the Dvorak technique as subjectively applied to enhanced infrared imagery (Dvorak 1984) in order to arrive at an objective T number, or "digital Dvorak" T number (hereafter referred to as DD numbers). Infrared imagery is available hourly from the GMS satellite, and hourly DD numbers were calculated for several of the typhoons of 1995 (including Oscar).

The DD numbers presented herein are experimental, and methods for incorporating them into operational practice are being explored. In some cases, the DD numbers differ substantially from the warning intensity and also from the subjectively determined T numbers obtained from application of Dvorak's technique. The output of the DD algorithm, when performed hourly, often undergoes rapid and large fluctuations. The fluctuations of the DD numbers may lay the ground work for future modifications to the current methods of estimating tropical cyclone intensity from satellite imagery. The discussion of the behavior of the time series of the DD numbers for Oscar, and for some of the other typhoons of 1995 (e.g., see the summaries of Polly (18W), Ryan (19W), Ward (26W), and Angela (29W)), is intended to highlight certain aspects of the DD time series that may prove to have important research and/or warning implications.

In Oscar's case, the DD numbers rise steadily from values in the low fives beginning at 141630Z

September to a peak in the mid-sevens within a period of a few hours either side of 151230Z September (Figure 3-17-5). Thereafter, the DD numbers fall quite steadily, and drop below T 4.0 after 0630Z on September 17. Compared with both the warning intensity, and the final best track intensity, one can see that the DD number and the warning intensity (converted to a T number) rise in tandem. As the DD numbers began to fall, the warning intensity did not reflect this fall, but remained consistently higher. Part of the reason for this is the requirement in Dvorak's scheme that the current intensity (i.e., real-time warning intensity) be held one T number higher than the diagnosed (or data) T number when that diagnosed T number is falling.

On a final note, notice that in the case of Oscar, the time series of the DD numbers is well-behaved: they steadily rise to a peak, and then steadily fall after the peak is reached. The hour- to-hour variation is within a few tenths of a T number, and few large fluctuations are noted. Also, the warning intensity and the DD numbers are consistent (as described in the previous paragraph). This is not always the case: for Super Typhoon Ryan (19W), there were large short-term variations, and the DD numbers were not consistent with the best track intensity (see the discussion section in Ryan's summary).

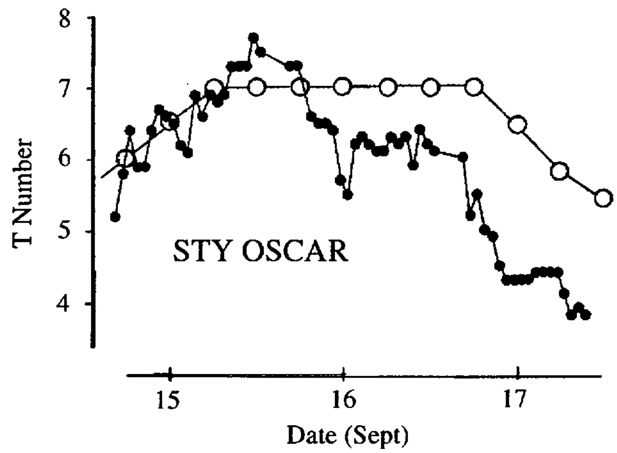

Figure 3-17-5 Hourly time series of the DD number obtained for Oscar during the period 141630Z September through 170930Z September (black dots), versus the final best track warning intensity (open circles).

IV. IMPACT

Sustained winds of typhoon intensity were recorded at exposed locations along the east coast of the Boso peninsula southeast of Tokyo. Winds at Narita airport and in the city of Tokyo did not exceed 50 kt (26 m/sec) sustained. The eye of Oscar passed near or over the island of Hachicho-Jima (WMO 47678) located about 90 nm (170 km) south of Tokyo; minimum sea-level pressure recorded was 938 mb.

Strong wind gusts and heavy rains associated with Oscar caused rail, air and ferry services to be suspended throughout the Kanto Plain. Press reports indicate that Oscar caused three deaths on land in Japan with six missing and feared dead in incidents at sea. Approximately 50 people were injured by falling debris (tiles blowing off roofs, and falling branches). Overall, only minor property damage was reported.